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ON THE INDUCED SPAWNING AND LARVAL REARING OF MILKFISH, *CHANOS CHANOS* (FORSKAL)

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ABSTRACT

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A female milkfish, captured at sea, was injected with two hormonal injections of acetone-dried salmon pituitary powder and human chorionic gonadotropin, plus Vitamin B complex. It was stripped, and produced 128,000 ripe eggs with an average diameter of 1.15 mm. Fertilization rate was 38% following artificial fertilization with milt from an uninjected male. A total of 36,000 larvae hatched (74% of fertile eggs) after 26—32 h at 34 ‰ salinity and 27—32°C. The newly hatched larvae measured 3.4 mm in mean total length and possessed a large yolk sac. The mouth of the larvae opened about 54 h after hatching. The larvae were fed with fertilized oyster eggs, rotifers, copepods, brine shrimp, flour and prepared feed, together with *Chlorella*. A critical period was between the 4th and 6th days with mortality over 80%. The larvae started increasing in length by Day 8, and had the appearance of the wild fry by Day 11. On Day 13 a pigmentation pattern developed and the biggest larva measured 10.0 mm. By Day 18 the larvae measured 12.5 mm, and 14.5 mm by Day 21. A total of 2,859 fry was obtained; the highest larval survival rate obtained from different experimental groups was 46.8%.

INTRODUCTION

The milkfish *Chanos chanos* (Forskal) is widely distributed in the semi-tropical and tropical regions of the world. It is cultured extensively in The Philippines, Indonesia and Taiwan. Milkfish is an important food fish in these countries and it is easy to cultivate. The only source of fry for the fish farms is the coastal waters during the spawning season and so the supply of fry is often irregular and inadequate. Experiments with induced breeding and artificial propagation of both captive (Liao and Chang, 1976; Nash and Kuo, 1976; Liao and Chen, 1979) and wild (Vanstone et al., 1976, 1977; Chaudhuri et al.,

1978) milkfish have been attempted to ensure a dependable source of fry to meet the growing demand.

Preliminary experiments by Vanstone et al. (1977) resulted in successful fertilization of stripped eggs, and the hatching of a few fingerlings. Chaudhuri et al. (1978) were also successful and reared two larvae to 6 days. This paper reports the successful induced breeding and artificial propagation of wild milkfish at Tigbauan (SEAFDEC) in 1978.

MATERIALS AND METHODS

Adult spawners

Four adult fish were available for work during the season. Three were captured at Lim-ao fish corral near Tigbauan on 22 May, the other was captured at Hamtik on 29 May. The fish were transported in plastic bags back to the research center. There, the fish were identified as one ripe male, two ripe females and one of undetermined sex. The female fish were not weighed to avoid excessive handling but body weights based on length were estimated for the calculations of hormonal injection levels to be used (Table I). None of the fish was in good condition and one female had a broken lower jaw.

Dosage and number of hormonal injections

The total dosages of hormones used were 6—24 mg/kg acetone-dried salmon pituitary powder (ADSP) and 400—800 IU/kg human chorionic gonadotropin (HCG), plus 0.5—1.0 ml Vitamin B complex. Injections were given to each female immediately and then at an interval of 12 h (Table I). Female No. 1 received two intramuscular injections below the dorsal fin; female No. 2 (the wounded fish) was injected four times but then died during the final procedures.

Egg collection, fertilization and incubation

Some eggs were found expelled from female No. 1 on the morning of 23 May. The fish was then stripped of the remaining eggs. The eggs were artificially fertilized with milt from the ripe male by the dry method. The fertilized eggs were collected in a fine scoop net and rinsed carefully with sea water of the same salinity used for subsequent incubation. They were then stocked in a 1.25-m diameter outdoor fiberglass tank of 0.7 ton water volume. Aeration was continuous. The water temperature throughout incubation ranged from 27 to 32°C, and salinity was maintained at 34 ‰.

As fertilized milkfish eggs float in sea water at salinities of 34 ‰ or above and unfertilized eggs sink, aeration in the incubator was stopped periodically for separation. All dead eggs were then removed.

Larval rearing

When half of the larvae were hatched, the emergent larvae were distributed among two large 1.25-m diameter tanks (0.7 ton) and eight small 1-m diameter tanks of 0.2 ton (Table IV). All but two these fiberglass tanks were located outdoors but protected under a roofed canopy.

The number of larvae stocked initially in each tank is shown in Table IV. On Day 1 green algae, *Chlorella* culture, were added to each tank. On Day 2 the larvae were provided with fertilized eggs and larvae of oysters and the rotifer, *Brachionus plicatilis*, as food organisms. After Day 14, flour, prepared feed, copepods (including *Cyclops* sp. and *Tigriopus japonicus*) and brine shrimp nauplii were given to the larvae.

During the rearing period aeration was continuous. The algal density of the water was maintained at a light green color by a daily addition of *Chlorella*, and food was given several times each day in measured quantities. Water quality was maintained by adequate sea water exchange and tank cleaning.

When the larvae were 21 days old, the visible organs and pigmentation patterns were more advanced than those of wild fry, but the lengths were similar. They were robust enough for stocking at that time and were therefore harvested and counted. The results are given in Table IV.

RESULTS AND DISCUSSION

Adult spawner

The adult fish used in the present experiment were obtained from different coastal places around the island of Panay. Safe capture, handling and transportation were therefore essential and important procedures. From previous experience, the fish are first harmed in the trap or corral and become highly stressed during transportation, particularly if captured in the spawning season. Nash and Kuo (1976) reported that the ovarian development of the female was seriously affected by stress. The eggs of female No. 2 attained a diameter of only 0.71 mm from the original 0.63 mm at capture, despite four injections. The poor health of this fish finally resulted in its death.

The season for catching milkfish in ripe condition in the Philippine coastal areas is March to November; but after June the weather is not always conducive because of the typhoons. Between March and May is therefore the best time to catch fish although there are still many problems such as injury and stress, or failure to catch both males and females simultaneously. The condition of the adult fish is also vital. The male used in the present work was ripe when captured but did not have a sufficient quantity of milt. It is therefore necessary for several males to be available.

Adult fish reared in tanks or ponds can be used successfully for breeding (Liao and Chen, 1979). Although it has not yet been proved with milkfish, injections of hormone to adult male grey mullet, *Mugil cephalus*, have been used

successfully to increase milt quantity (Shehadeh et al., 1973; Liao, 1975) and successful cryopreservation results will help to solve the problem of the lack of suitable live adults of either sex at the required time.

With careful handling the adult milkfish female can survive after being stripped. It would be very beneficial to use the same fish year after year as it takes from 5 to 6 years to raise a mature broodstock fish from a juvenile (Liao and Chang, 1976; Liao and Chen, 1979).

Dosage and interval of hormonal injections

The hormones and dosages used to induced spawning of the females are given in Table I. More ADSP than HCG is recommended in the first injection, and vice versa for the second and subsequent injections. Adjustment is made depending on observed oocyte changes after sampling.

Before an injection is given, it is important to estimate the body weight of the fish in order to calculate the hormone dosage per unit body weight. The dosage used for female No. 1 (Table I) is suggested for a fish with eggs of 0.75 mm diameter. For female No. 2 the dosage seemed to be insufficient. Compared with previous induced spawning experiments on milkfish, the improvement in the present procedure was the injection of Vitamin B complex. Although the function of Vitamin B complex is not very well understood, it appears that it is beneficial to fish under the stress of handling and injection (Liao, 1976).

The interval between injections was about 12 h. The results indicated that this interval was adequate for females with eggs of 0.75 mm diameter (or larger) before injection. For females with eggs of diameter less than 0.75 mm, a longer interval might be more suitable. Only ADSP was tested on the two fish. However, both ADSP and acetone-dried mullet pituitary (ADMP) were tried by Liao and Chen (1979), and ADMP was also effective.

Egg collection, fertilization and incubation

It is often difficult to judge external morphological responses of fish to hormone injection and to estimate the right time for stripping. Unlike the grey mullet (Liao et al., 1972; Kuo et al., 1973), the milkfish responding to hormonal injection has only slight distension of the abdomen. The grey mullet female also exhibits different swimming behavior before spawning, but the milkfish does not. Careful observation of the behavior of the milkfish spawners before ovulation is still required.

In this experiment eggs were fertilized artificially by the dry method. This method was chosen to make the most use of the small quantity of milt from only one ripe male. It is possible that the milt volume of milkfish males is naturally low. Schuster (1960) reported that the milkfish is a polygamous species and breeding occurs in schools. The low fertilization rate of 38% obtained was possibly due to the small volume of milt available.

TABLE I

Record of induced spawning events of milkfish

Fish no.:	1	2
Fork length (cm):	77.2	90.0
Body weight (kg):	6.5 (7.0*)	9.8 (7.5*)
Egg diameter (mm):	0.75	0.63
Date and time of 1st injection: Dosage:	22 May 1978 — 06.35 h 42 mg ADSP 2,800 IU HCG 0.5 ml Vit. B	29 May 1978 — 16.00 h 45 mg ADSP 1,500 IU HCG 0.5 ml Vit. B
Date and time of 2nd injection: Dosage:	22 May 1978 — 18.40 h 42 mg ADSP 4,200 IU HCG 0.5 ml Vit. B	30 May 1978 — 04.45 h 45 mg ADSP 3,000 IU HCG 0.5 ml Vit. B
Date and time of 3rd injection: Dosage:	None	30 May 1978 — 16.00 h 45 mg ADSP 3,000 IU HCG 1.0 ml Vit. B
Date and time of 4th injection: Dosage:	None	31 May 1978 — 04.00 h 180 mg ADSP 6,000 IU HCG 1.0 ml Vit. B
Date/spawning time:	23 May 1978 — 05.30—06.30 h	Died
Date/fertilization time:	23 May 1978 — 07.00 h	—
Estimated no. of fertilized eggs:	48,000 (38%)	—
Date/hatching time:	24 May 1978 — 08.45—15.00 h	—
Estimated no. of hatched larvae from fertile eggs:	36,000 (74%)	—

*Estimated body weight before first injection.
ADSP: Acetone-dried salmon pituitary powder.
HCG: Chorionic gonadotropin, A.P.L. Ayerst Lab.
Vit. B.: Vitamin B complex, HI-B CON Forte.

According to Delsman (1926, 1929) milkfish eggs collected at sea had a diameter of 1.2 mm; Chacko (1950) mentioned 1.1—1.2 mm diameter. Nash and Kuo (1976) reported 1.2 mm diameter for hydrated eggs; Vanstone et al. (1977) stated 1.1—1.23 mm (mean 1.16); Chaudhuri et al. (1978) quoted 1.1—1.25 mm (mean 1.13 mm); Liao and Chen (1979) reported an average of 1.19 mm. In this study the eggs from female No. 1 had a diameter of 1.13–1.19 mm (mean 1.15 mm). The diameter of hydrated milkfish eggs, therefore, is in the range of 1.10 to 1.25 mm.

The observed development of the milkfish embryo was similar to that described for many other pelagic fish eggs (Fig. 1 B—K and Table II). The first cleavage occurred about 1 h after fertilization with subsequent cleavages occurring at intervals of 5—25 min. As the embryo formed, the first movements of the embryo were observed approximately 21 h 30 min after fertilization.

During incubation of the eggs, two thirds of the water volume in the incubators were changed periodically with water of the same salinity and temperature. The incubators were surrounded by a bamboo mat to protect the larvae from strong sunlight. About 25 h 45 min after fertilization the first larvae hatched, and by 29 h more than 60% of the larvae hatched. The remainder hatched 32 h after fertilization. A total of 36,000 larvae hatched and the hatching rate was estimated to be 74% (Table I) of the fertilized eggs.

Vanstone et al. (1977) noted that incubation time ranged from 35 to 36 h at 28.4—29.2°C; Chaudhuri et al. (1978), 25—28.5 h at 26.4—29.9°C. Delsman (1929) and Senta et al. (1976) reported that most of the milkfish eggs collected in coastal waters hatched in the evening of the day of collection. These facts would indicate that the spawning time of milkfish in nature is in the evening. Delsman and Hardenberg (1934) and Schuster (1960) drew the same conclusion.

The newly hatched larvae of milkfish measured 3.4 mm in mean total length and carried a large yolk sac of about 2.20 mm long and 0.28 mm wide. Two hours after hatching the larvae gained in length, and about 34—35 preanal myotomes were observed. After 12 h the body length reached the range of 4.7—5.3 mm, and the yolk sac was greatly reduced. Within the first day

TABLE II

Development of milkfish embryo at 27—32°C and 34‰

Time after fertilization h.min	Stage of development	Photo No. in Fig. 1
0	Fertilized egg	A
1.00	2-cell	B
1.06	4-cell	C
1.35	16-cell	D
3.23	Many-cell	
5.30	Blastula	E
6.00	Gastrula, germ ring formed	F
8.00	Late gastrula, yolk invasion 2/3 complete	G
10.35	Early embryonic body formation	H
12.00	12 myomeres	
14.35	C-shaped embryo, 22 myomeres, optic and otic vesicles formed	I
21.30	Late embryonic development, embryo begins twitching movement	J
25.45	Hatching, embryo fully formed emerging from egg shell	K

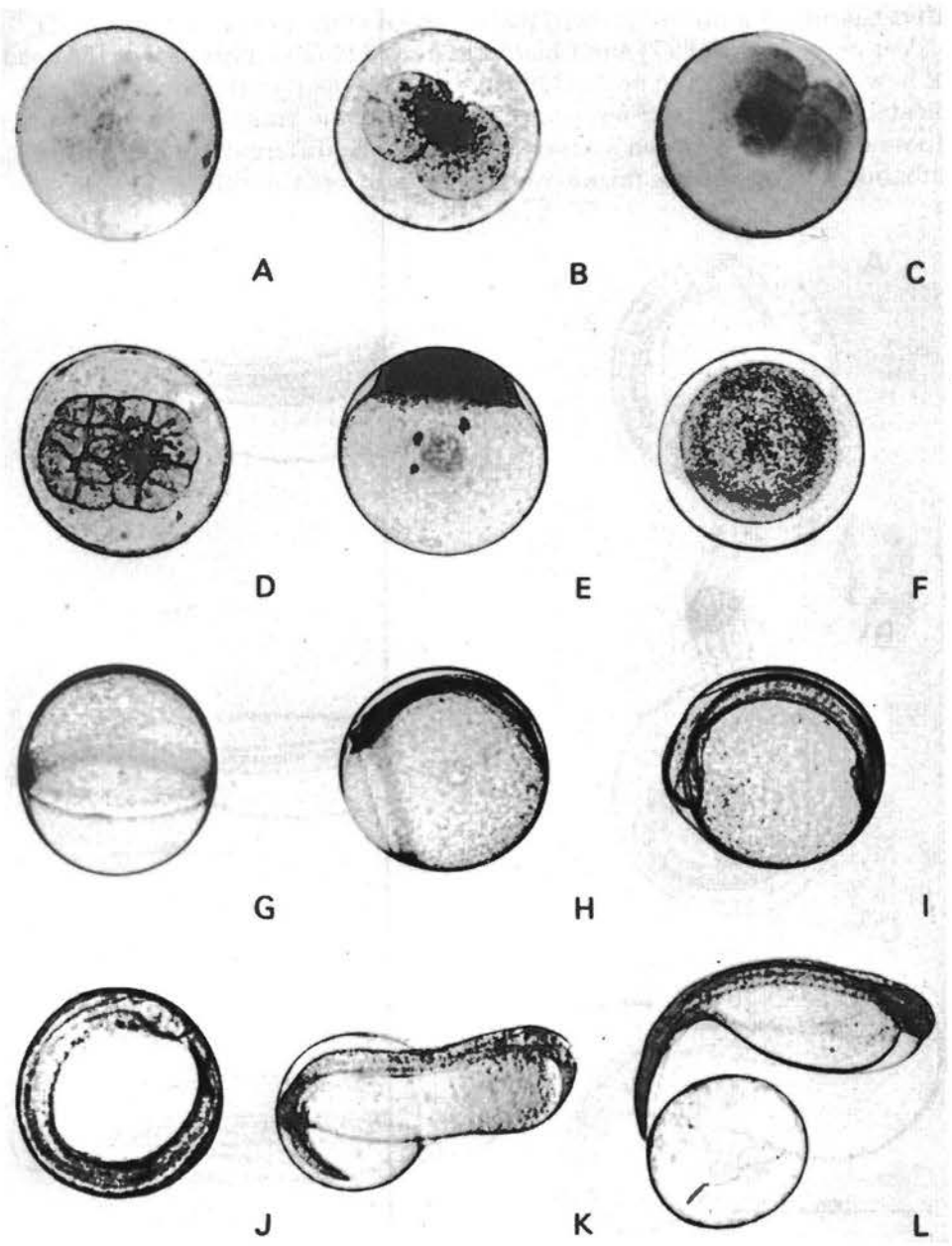

Fig. 1. Embryonic development and hatching of milkfish. (A) Fertilized egg, 1.13—1.19 mm in diameter. (B) 2-cell stage. (C) 4-cell stage. (D) 16-cell stage. (E) Blastula stage. (F) Gastrula stage. (G) Late gastrula stage. (H) Early embryonic body formation. (I) C-shaped embryo. (J) Late embryonic development. (K) Hatching. (L) Newly-hatched larva and egg shell.

after hatching significant growth was recorded (Fig. 2 D—F and Table III).

Vanstone et al. (1977) and Chaudhuri et al. (1978) reported that the head of newly hatched larvae protruded beyond the yolk sac. Delsman (1929) indicated that the head did not project in front of the yolk. The present work does not support Delsman's observations, but the different durations of incubation and conditions might contribute to different results.

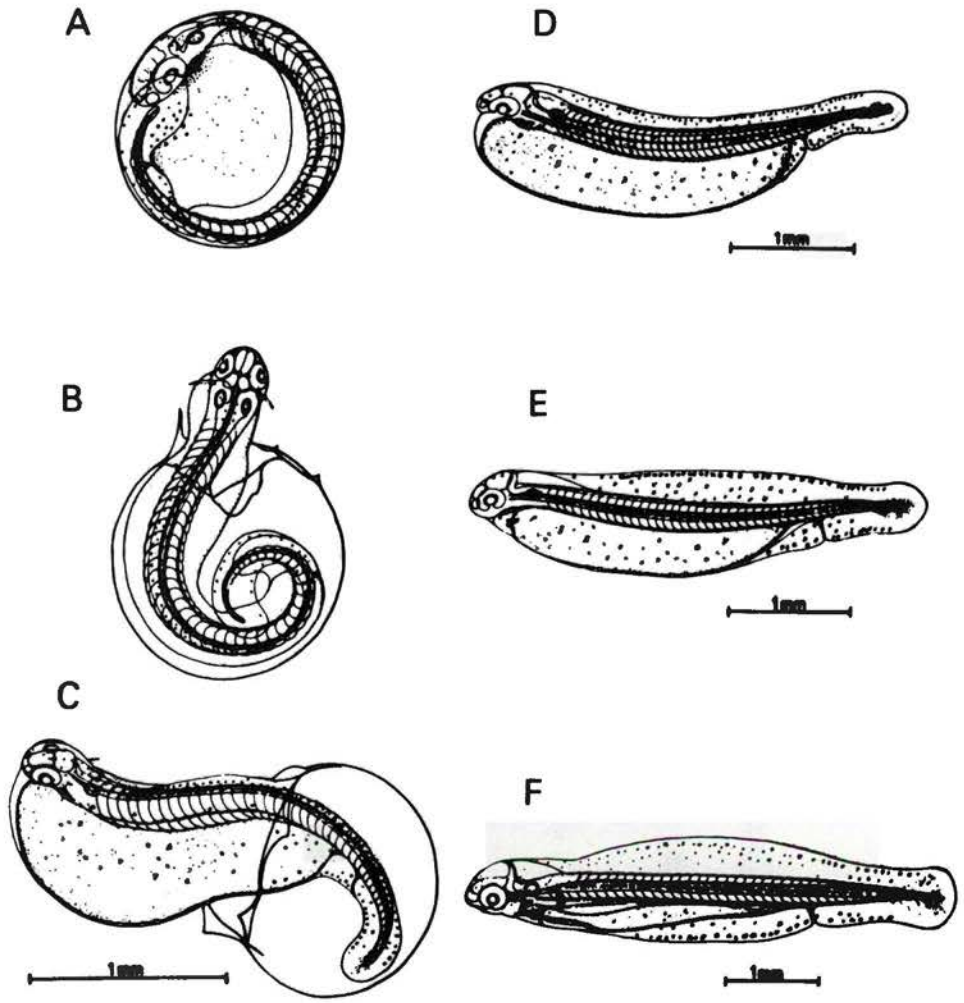

Fig. 2. Embryonic and larval development of milkfish. (A) Immediately before hatching. (B) Hatching with head emerging from egg shell. (C) Partially hatched and egg shell. (D) Newly hatched, total length 3.4 mm. (E) 2 h old, 3.7 mm. (F) 12 h old, 5.3 mm.

TABLE III

Larval development and behavior of milkfish

Days after hatching	Total length (mm)	Food*	Development and behavior	Remarks
0	3.2—5.3	—	Larva slightly curled. Eyes unpigmented. Mouth not formed. Anus closed. Head protrudes ahead of yolk sac. Melanophores distributed over the finfold except at the posterior part of the caudal region. Two hours after hatching the dorsal finfold broadens, body length increases. Yolk sac of 12-hour-old larva reduces greatly. Gill arch developing. Rudiment of pectoral fins visible. Caudal part of finfold slightly constricted.	Fig. 2 B—F
			Larvae remain in suspension head down near the water surface and sink slowly in an oblique position with belly up; make quick 360° upward turn and swim rapidly to the water surface. Movement often repeated.	Fig. 5 A
1	4.9—5.3	G	Eyes still unpigmented. Caudal part of finfold more constricted. Yolk sac reducing. Rudimentary pectoral fins starting to develop. Anus still closed. Xanthophores distributed over the dorsal part of the head. Most of the melanophores are lined at the margin of the dorsal and ventral finfold. The posterior portion of the caudal finfold remains unpigmented.	Fig. 3 A
2	5.0—5.4	G,O,R	Eyes start to be pigmented. Rudimentary lower jaw prominent. Mouth and anus opened. Membrane of pectoral fins appears. Yolk reduced. Heart chambers differentiating. Two rows of branched or punctate melanophores are found on both dorsal and ventral part of the trunk and stellate melanophores at the posterior part of the body.	Fig. 3 B
			Larvae make sudden 360° horizontal turn and rest in midwater near the surface or near the bottom.	Fig. 5 B
3	5.0—5.5	G,O,R	Yolk completely absorbed. Feeding behaviour conspicuous. Eyes well pigmented. Air bladder starts to form. Pigmentation at peripheral region decreases. One row of melanophores is present along both the dorsal and ventral edge of the myotomes.	Fig. 3 C
			Larvae show phototaxis and rheotaxis during daytime but drift during night-time. Threshold of critical period.	Fig. 5 C and D

TABLE III (continued)

Days after hatching	Total length (mm)	Food*	Development and behavior	Remarks
4—5	4.3—5.8	G,O,R	Heart chamber well developed. Reflection of optic lens perceptible. Cartilaginous hypural elements visible. No further differentiation in finfold. Healthy larvae show strong feeding activity. Critical period occurs between the 4th and 6th day usually with 80% mortality or more.	Fig. 3 D and E
6—7	5.0—6.2	G,O,R	Rudimentary gill filament visible. Pectoral fins well developed. First sign of bilobal caudal fin visible. Hypural bones and their associated actinotrichia developing. Some actinotrichia appear in posterior dorsal and ventral part of finfold. Critical period ends.	Fig. 3 F and G
8—9	5.4—7.0	G,R	Rudimentary urostyle flexes, and both actinotrichia and lepidotrichia appear. A single otolithic melanophore appears. Operculum forming. Pigmentation of dorsal part disappearing except in the posterior region which is still prominent. Growth starts to accelerate.	Fig. 3 H and I, Fig. 6
10	5.9—7.5	G,R	Differentiation of dorsal and anal fins from the common finfold begins. Number of lepidotrichia in dorsal part 9—10, in ventral part 5—6. Flexion of rudimentary urostyle advances. Caudal fin more differentiated and pigments between the caudal fin rays become more prominent. Body becomes very transparent and stomach contents visible.	Fig. 3 J
			Larvae swim in schools and show strong rheotaxis in daytime.	Fig. 5 C
11	6.7—8.8	G,R	The dorsal and anal finfolds separate from caudal finfold and actinotrichia more developed. Posterior margin of caudal fin slightly concave. Heavy pigmentation between well developed actinotrichia. Pseudobranch visible. Body transparent and assumes a wild fry-like pigmentation pattern. Feed only in daytime.	Fig. 4 A

12—13	6.2—10.0	G,R	Caudal finfold separates completely from the dorsal and anal finfolds, and rays developing. Three segments in caudal fin rays visible. Pigmentation on the dorsal portion of trunk increases, but reduces on the dorsal peritoneal membrane except in the region above the air bladder and the posterior portion of anus. Air bubble appears in air bladder. Variations in size and growth rate of larvae apparent.	Fig. 4 B and C
			Larvae continue to drift in night-time.	Fig. 5 D
14—15	6.4—11.8	G,R,C,F,P,B	Development of fins resembles that of wild fry. Pigmentation on the mediolateral portion appears in the caudal region and proceeds anteriorly. Growth accelerates again in this stage.	Fig. 4 D and E, Fig. 6
			Larvae swim more swiftly and circularly in daytime and swim slowly to counter current in night-time. Larvae show strong phototaxis also in night-time. Larvae still too weak for stocking in ponds.	Fig. 5 E and F
16—17	9.5—13.2	G,R,C,F,P,B	Red blood cells visible so that 'the spleen' and the main trunk artery and vein appear reddish. Pigmentation on head region increases. Intestinal wall folds increase and become more distinct. Partitioning of nostrils evident. Rudimentary gill rakers visible. Five segments on caudal fin rays.	Fig. 4 F and G
			Larvae very active and react to sudden movement.	
18—20	10.3—14.9	G,R,C,F,P,B	First sight of intestinal fold. Nostrils partitioned. Rudimentary pharyngeal organs developing. Rudimentary pelvic fins visible. Pigmentation pattern differs from that of wild fry.	Fig. 4 H and I
			Larvae no longer sensitive to direct exposure to sunlight. Prefer to feed on algae growing on the tank wall. Body weight heavier than that of wild fry of similar total length.	Table V
21	13.5—16.5	G,R,C,F,P,B	Pelvic fins developing. Pigments scattered over the upper half of the body and dense on peritoneal wall. Six segments on caudal fin rays. Development stage 5—10 days more advanced than that of wild fry of similar size.	Fig. 4 J
			Larvae strongly resistant to handling and adverse environmental condition. Suitable for stocking in ponds.	

*G: Green algae. O: Oyster fertilized egg and its larva. R: Rotifer. C: Copepod. F: Flour. P: Prepared feed. B: Brine shrimp.

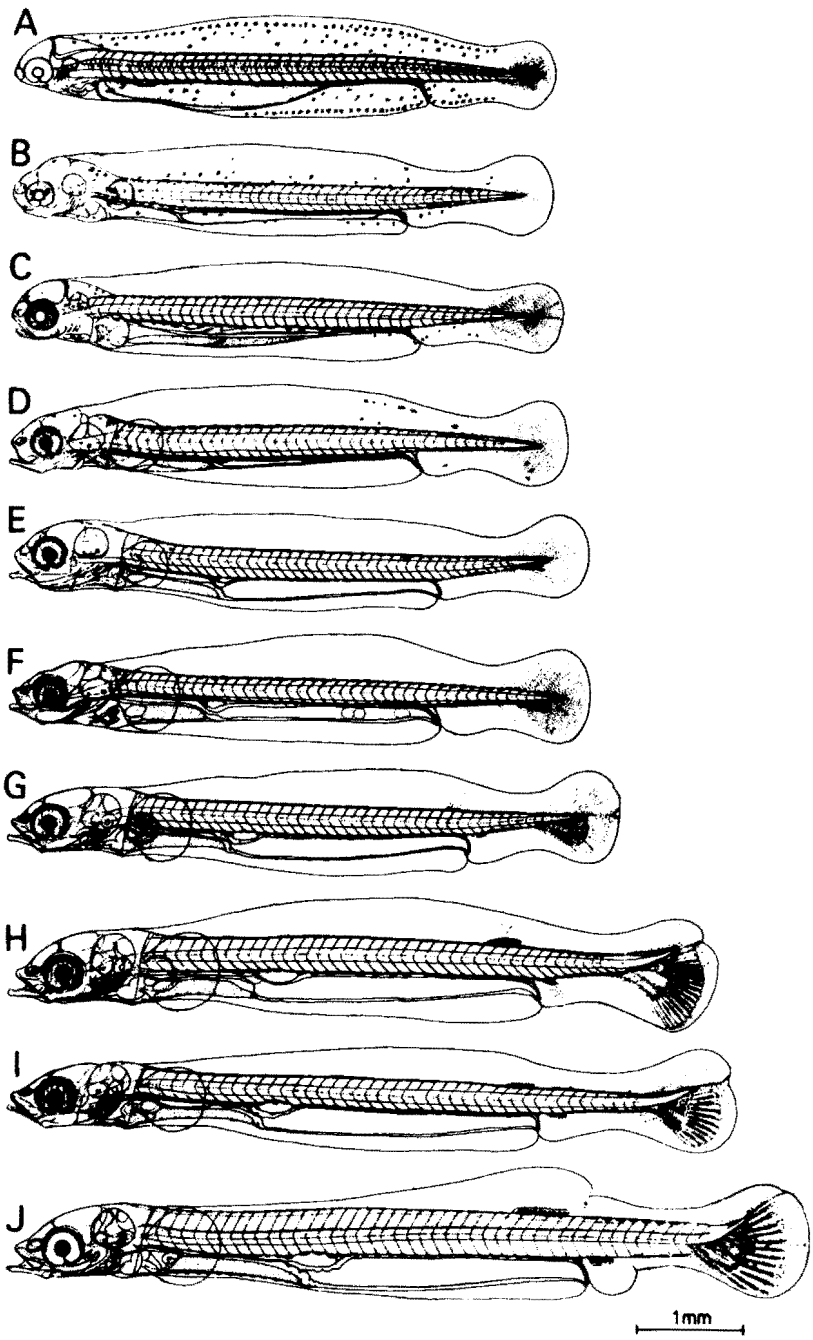

Fig. 3. Larval development of milkfish. (A) 1 day old, 5.1 mm. (B) 2 days, 5.1 mm. (C) 2.5 days, 5.2 mm. (D) 3.5 days, 5.3 mm. (E) 4.5 days, 5.4 mm. (F) 6 days, 5.4 mm. (G) 7 days, 5.7 mm. (H) 8 days, 6.6 mm. (I) 9 days, 6.8 mm. (J) 10 days, 7.5 mm.

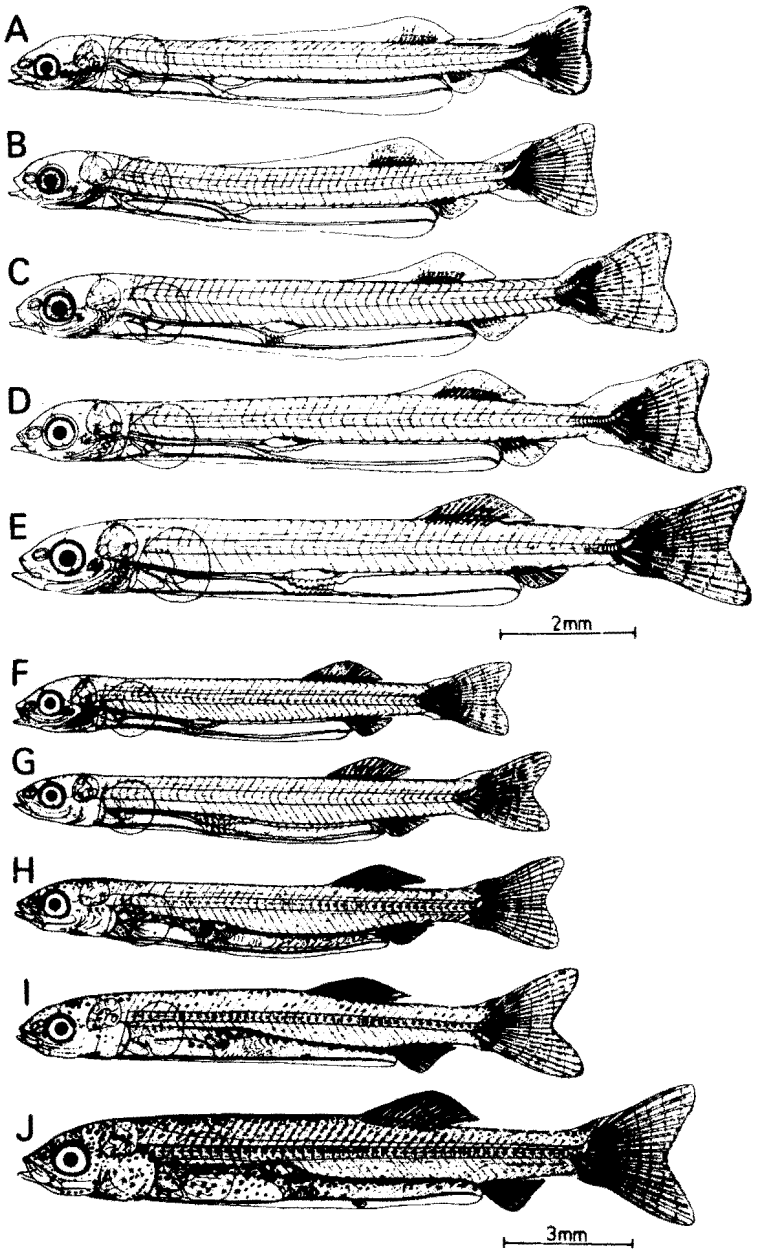

Fig. 4. Larval development of milkfish. (A) 11 days, 8.8 mm. (B) 12 days, 9.1 mm. (C) 13 days, 10.0 mm. (D) 14 days, 10.5 mm. (E) 15 days, 11.0 mm. (F) 16 days, 11.7 mm. (G) 17 days, 12.6 mm. (H) 18 days, 12.9 mm. (I) 19 days, 13.3 mm. (J) 21 days, 15.9 mm.

Larval rearing

The emergent larvae were immediately active. The larvae were transparent with little pigmentation. Swimming larvae followed a characteristic behavior, remaining head down in suspension near the water surface and then sinking very slowly. Upon reaching a depth of about 5—8 cm, the larvae made a sudden upward turn and moved back to the water surface headfirst. The larvae also made jerky motions occasionally (Table III and Fig. 5 A).

The larval development and behavior observed in the present experiments are summarized in Table III and Fig. 5. During the rearing period the pH was 8.1—8.3, and the water temperature ranged from 27.1 to 29.5°C (Fig. 6). Early development, increase in length, and reduction in yolk were rapid within 24 h after hatching. By 36 h the rudimental pectoral fins started developing, and the eyes became pigmented. Throughout the first 2 days the larvae were passive, resting head downwards and upside down. At 48 h the larvae moved forward weakly and occasionally turns of 360° were observed. The anus opened and the mouth appeared to be formed. At 54 h the mouth opened, and by 72 h food was visible in the stomach.

Starting on Day 1 *Chlorella* was added to all the rearing tanks. The density in the rearing tanks was between 50 and 350×10^4 cells/l. Although *Chlorella* was added until Day 21 to maintain water quality and provide food for the rotifers that were consumed by the larvae, there was no evidence that the larvae fed directly on them. On Day 2 fertilized oyster eggs and larvae as well as rotifers were given. Young fish larvae, with a newly opened mouth measuring 200 μm, were able to feed on the small rotifers (80—200 μm). In one trial, groups of larvae were given fertilized oyster eggs and larvae at a density of 30—300 organisms/cc, together with rotifers at 10—200 organisms/cc, for the first 6 days; other groups were given rotifers exclusively at 10—200 organisms/cc Although both rations were apparently good for rearing young larvae successfully, the latter gave a lower survival rate (Table IV). As shown in Table IV and Fig. 6, groups of 14-day-old larvae (or older) were given copepods (200—600 μm) collected from coastal areas, cultured copepods *Tigriopus japonicus* (120—1,500 μm), brine shrimp nauplii (160—1,000 μm), as well as flour and prepared feed.

Between Days 3 and 6, the larvae showed little change in total length and apparently began a critical period. This period lasted for 2—3 days. Mortality was over 80% in one tank. By Day 8 the length gain of the larvae accelerated, and the biggest 10-day-old larva was 7.5 mm in total length. By this time the larvae looked transparent, swam in a school, and showed strong rheotaxis in daytime. The 11-day-old larvae looked more transparent and their pigmentation pattern resembled that of wild fry. The largest larvae after 13 days measured about 10.0 mm in total length and were considered to be fry. The small wild fry collected at Hamtik coastal area were of the same size.

Development of the fins on 14—15-day-old larvae resembled those of wild fry. Changes in swimming behavior were observed (Fig. 5 E and F), but the

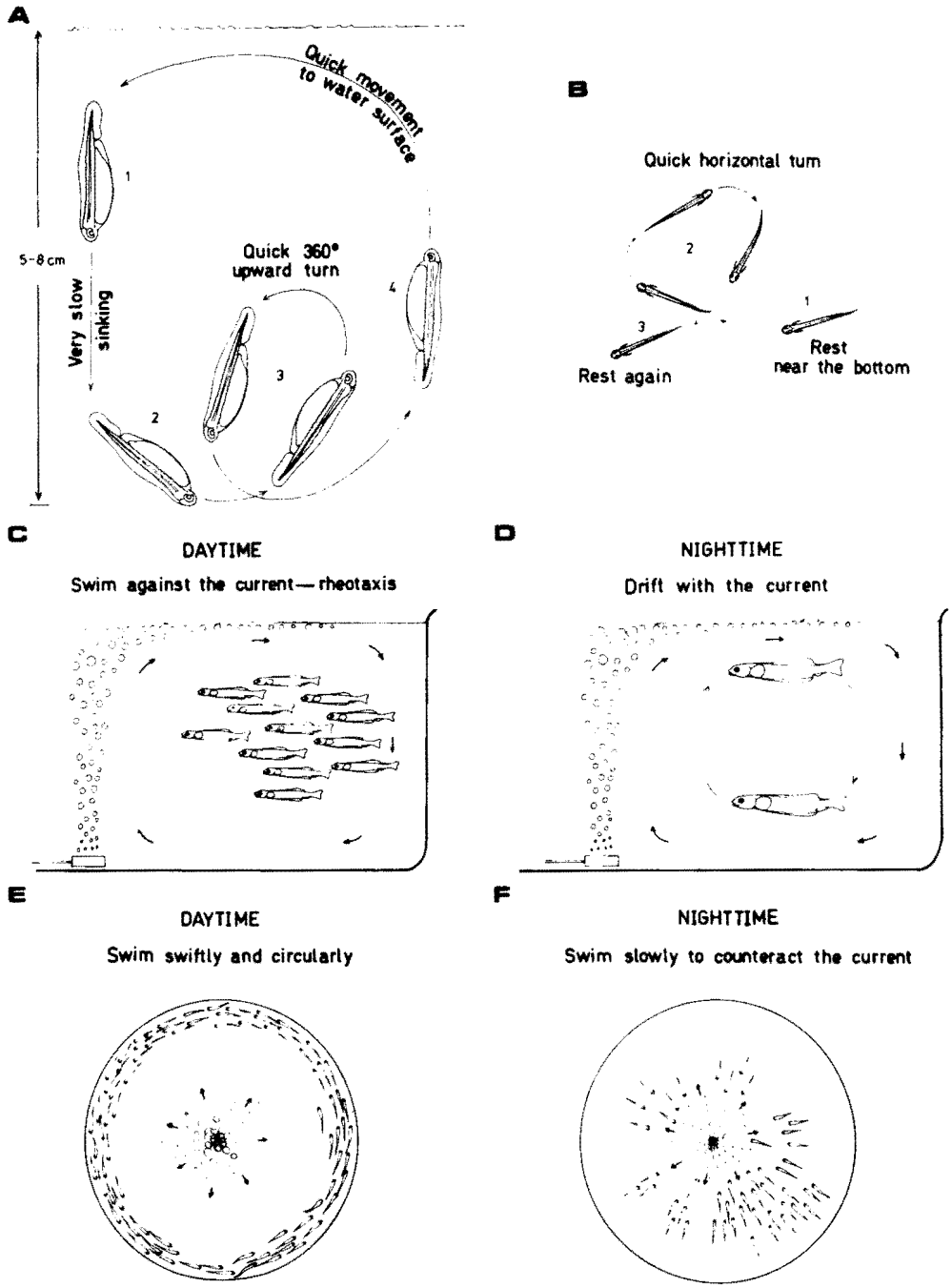

Fig. 5. Larval behavior of milkfish. (A) From Day 0 to Day 1. (B) On Day 2. (C) From Day 3 to Day 13 in daytime. (D) From Day 3 to Day 13 in night-time. (E) After Day 14 in daytime. (F) After Day 14 in night-time.

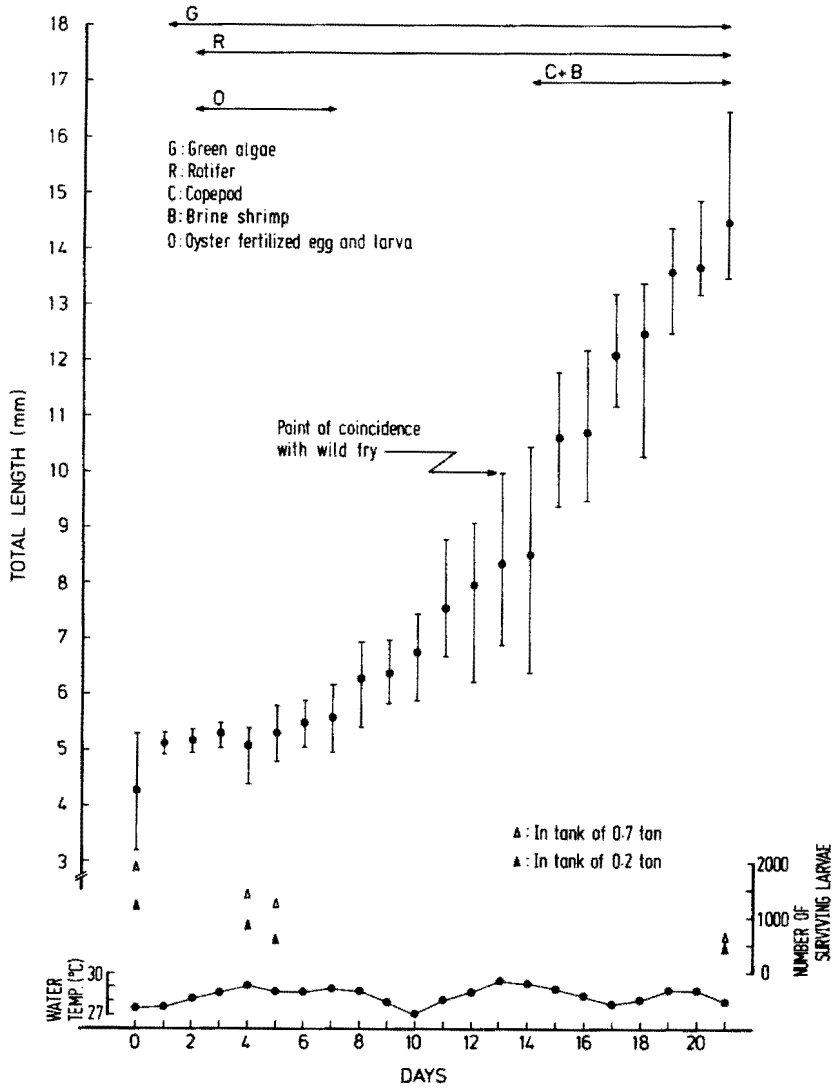

Fig. 6. Food supply, water temperature, survival and growth in laboratory reared milkfish larvae.

larvae still showed strong phototaxis. They were not yet strong enough for harvesting and transfer to ponds. The 18—20-day-old larvae had similar body length to wild fry and no longer reacted to strong sunlight. Their pigmentation pattern was more pronounced than that of wild fry, and body weight was about twice that of wild fry of similar total length (Table V).

The 21-day-old fry measured 13.5—16.5 mm (mean 14.5 mm) in total length, still within the range of wild fry. The distinguishing characteristics were the pelvic fins that were visible 5—10 days in advance of the fins of the

TABLE IV

Larval survival under varying conditions of density and feeding regimes of milkfish

Tank no.	Tank volume (ton)	Outdoors or indoors	Feeding regime	Initial stocking density	Total harvested (Day 21)	Total harvested and sampled*	Survival rate on Day 21 (%)
1	0.7	Outdoors	G,O,R	1900	612	889	46.8
2	0.7	Outdoors	G,O,R	1900	593	615	32.4
3	0.2	Outdoors	G,O,R,F	1200	214	225	18.8
4	0.2	Outdoors	G,O,R	1200	262	267	22.3
5	0.2	Outdoors	G,R	1200	103	105	8.8
6	0.2	Outdoors	G,2R,P	1200	342	348	29.0
7	0.2	Outdoors	G,3R	1200	137	155	12.9
8	0.2	Outdoors	G,O,R,C,B	1200	408	483	40.3
9	0.2	Indoors	G,O,R	1200	122**		
10	0.2	Indoors	G,O,R	1200	306**		

G: Green algae. O: Oyster fertilized egg and its larva. R: Rotifer. F: Flour. 2R: Double quantity R. 3R: Triple quantity R. P: Prepared feed. C: Copepod. B: Brine shrimp.
*All larvae sampled during the rearing period were alive at the time of sampling.
**On Day 13, the experiment was terminated due to bad growth.

TABLE V

Comparison of body weight between artificially propagated and wild milkfish fry with similar total length

Fry	No.	Total length (mm)	Body weight (g)	Body weight/ Total length $\times 10^3$
Artificially propagated fry	1	14.4	0.0102	0.71
	2	14.4	0.0109	0.83
	3	14.6	0.0104	0.71
	4	14.6	0.0106	0.73
	5	14.6	0.0111	0.76
Wild fry (Liao et al., 1977)	6	14.4	0.0052	0.36
	7	14.4	0.0060	0.42
	8	14.5	0.0058	0.40
	9	14.7	0.0067	0.46
	10	14.7	0.0071	0.48

wild fry. The wild fry had no pelvic fins on capture, but they formed within 5—10 days (Delsman, 1929; Kumagai et al., 1976; Liao et al., 1977). The young fry, about 20 days old, were robust enough for stocking. The experiments on larval rearing were therefore concluded on Day 21.

There are few records of milkfish larval development. Delsman (1929) and Schuster (1960) described data on early stages of larvae collected over prolonged periods. Vanstone et al. (1977) and Chaudhuri et al. (1978) reported embryonic and pre-larval development. This paper describes the first complete continuous record of development of milkfish larvae to the fry stage.

There is no previous report on successful mass propagation. In this study, a total of 2,859 21-day-old larvae suitable for stocking was obtained; the highest survival rate obtained from different experimental groups was 46.8% (Table IV).

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